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Using Inefficiencies in Telecoms Product Life Cycle as Determinants of Strategies for Increasing Revenues from Telecoms: A Methodology and an Illustrative Example

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USING INEFFICIENCIES IN TELECOMS PRODUCT LIFE CYCLE AS DETERMINANTS OF STRATEGIES FOR INCREASING REVENUES FROM TELECOMS: A METHODOLOGY AND AN ILLUSTRATIVE EXAMPLE

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ABSTRACT

Generation of revenues is one of the most obvious routs by which investments in Information and Communication Technologies (ICT) contribute to the macroeconomic bottom line. However, due to the heterogeneity of the Transition Economies (TE), the strategies directed at the increase of the level of revenues from investments in ICT tend to be context-specific. In this paper, we propose and test a methodology allowing for formulation of the strategies based on the identification of the least efficient areas of the S-curve of the Product Life Cycle model. The proposed six-step methodology utilizes such widely used in Information Systems research data analytic techniques as Data Envelopment Analysis (DEA), Neural Networks (NN), and Multivariate Regression (MR). Illustrative example in the context of18 TEs demonstrates our methodology in action.

Keywords

Investments in Telecoms, Revenues from Telecoms, Efficiency, DEA, product life cycle, transition economies

INTRODUCTION

In *transition economies* (TE) macroeconomic outcomes of investments in ICT have been mixed. Some of these countries, viz. Poland, Czech Republic, Hungary, and Slovenia, seem to be able to benefit from investments in ICT to a greater extent than other TEs that struggle to exhibit any significant results of such investments on a macroeconomic scale (Piatkowski, 2003). Revenue generation serves as one of the major means by which investments in ICT contribute to macroeconomic growth (UN ICT Task Force Report, 2005; WT/ICT Development Report, 2006). However, the context of TEs differs from a relatively homogenous environment of developed economies that allows for easier sharing of the successful strategies and best practices. Consequently, the formulation of the specific strategy of increasing the level of revenues in the context of TEs requires identifying existing inefficiencies in the process of revenue production, then choosing an appropriate course of action that will lead to improvements in efficiency. In this investigation we concentrate on the relationship between investments in Telecoms, and revenues that are associated with the sales of a Telecom product. We define a *Telecom product* as any *Telecom-related product or service introduced for the purposes of satisfying customer needs*. Broadly, the research question of our investigation can be outlined as follows: *How to determine an empirically justifiable strategy of increasing the level of production of revenue from the sale of Telecom products in the context of TEs?* To answer this research questions, we propose a six-step methodology using *multivariate regression* (MR), *data envelopment analysis* (DEA), and *neural networks* (NN). The rest of this paper is structured as follows. First we offer brief description of the product life cycle (PLC) model. Next we describe the proposed methodology and provide an illustrative example. A brief conclusion follows.

THEORETICAL FRAMEWORK

The Product Life Cycle (PLC) Model

In this paper, we adopt a definition of the product life cycle model as a "time dependent model of the volume of sales and earnings during different stages of the life of a certain product" (Bescherer, 2005). The product life cycle model is commonly represented as consisting of either four or five stages. A four-stage PLC model is similar to the five-stage model (see Figure 1), with the difference that a four-stage model integrates the *Saturation* stage into the *Maturity* stage.

The actual *Sales* curve may vary from the generic shape of the general PLC curve. Despite such variations, however, the distinctive S-shape of the PLC *Sales* curve is commonly observed. Indeed, Hauser *et al*. (2005), after review of Rogers (2003), Sultan *et al*. (1990), Van den Bulte and Stremersch (2004), point out an emerging consensus among researchers that the *Sales* curve over PLC is usually S-shaped and that the "S-shaped curve seems to hold for successive generations of the product."

OVERVIEW OF THE METHODOLOGY

In order to answer the research question of this study, we propose a six-phase methodology. Each of the phases is described below. Due to the relativity of the concept of efficiency, our methodology requires the presence of the initial condition specifying a benchmark of efficiency.

Initial Condition

Initial condition requires presence and identification of:

1. a High-performing entity, or a group of entities ("Leaders"), and
2. a Low-performing entity, or a group of entities ("Followers")

   Such as

Averaged Relative Efficiency of *Leaders* > Averaged Relative Efficiency of *Followers*

Phase 1: Identifying the Existing Inefficiencies

The first phase uses output-oriented DEA to determine the area of the greatest relative inefficiency in production of revenues on the PLC curve. In order to do so, we obtain the scores of the relative efficiencies for each decision making unit (DMU) in the sample, assign the scores to the appropriate group (i.e. *Leaders* or *Followers*), and then average the scores for each group. This allows us to obtain three separate average scores per group, one each under assumptions of constant (CRS), variable (VRS), and non-increasing (NIRS) return to scale. We then determine under what assumption of return to scale the difference between the three averaged scores is the greatest. By mapping this area of the greatest difference to the PLC curve, we determine the area of the greatest inefficiency of revenue production on the PLC curve. Figure 1 below illustrates the suggested approach.

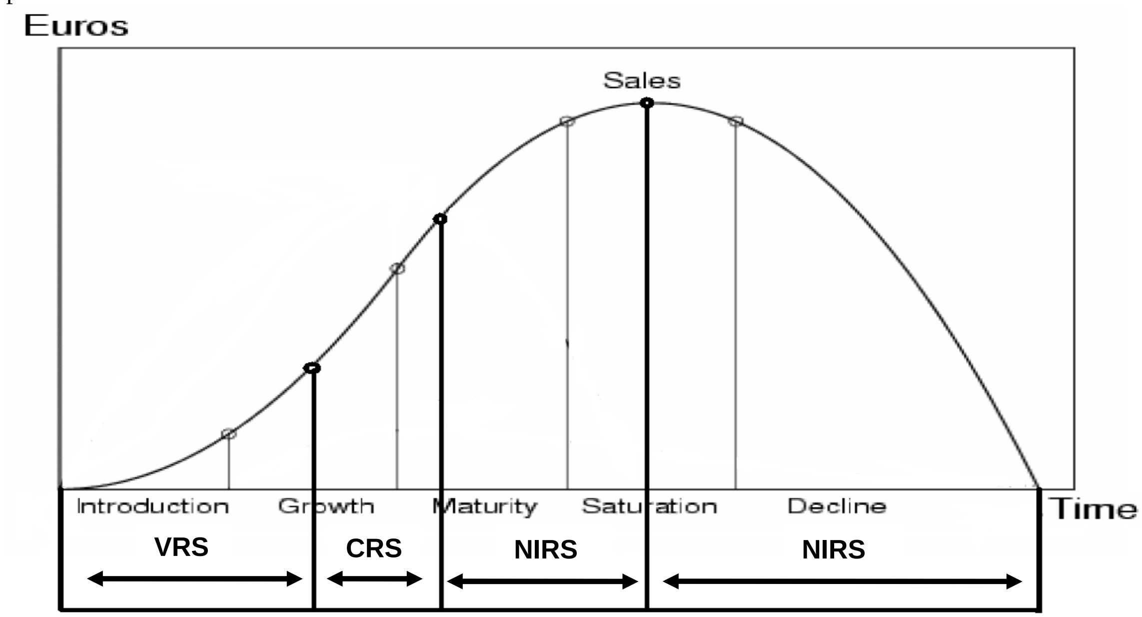

Figure 1 Suggested Mapping of the Results of DEA to the areas of PLC Curve for the Purposes of Identification of the Area of the Greatest Relative Inefficiency(rendering of the Five-stage product life cycle model adopted from Meffert (2000))

Phase 2: Modeling the Revenue Production Process

In the second phase we create two NN models, one for the *Followers* and one for the *Leaders*. Inputs and outputs of DMUs in the sample, which represent DEA model, provide us with the set of input and output nodes for NN. The resulting transfer functions represent the models according to which inputs of the *Followers* and the *Leaders* are converted into their respective outputs.

Phase 3: Simulating the New Level of Revenues

In the third phase we use the NN model created for the *Leaders* and the input values of the *Followers*, to simulate what the outputs would have been for the *Leaders*, if they had the input resources of the *Followers* but used their own, more efficient process of conversion. Thus we end up with three sets of outputs: (1) the original set of inputs and outputs for each DMU in the sample, (2) the hypothetical outputs of the *Leaders* based on the conversion process of the *Followers*, and (3) the hypothetical outputs of the *Followers*, based on the conversion process of the *Leaders*.

Phase 4: Determining the Sources of Inefficiency

In the fourth phase we subject the simulated data sets obtained in the third phase to DEA. Comparing the resultant averages of relative efficiencies, we determine which set offers the smallest difference in terms of the levels of relative efficiencies. Thus, we determine whether the *Followers* would benefit more from an increase in the level of investments (inputs), or whether they would benefit more from improving the process by which investments (inputs) are converted into revenues (outputs).

Phase 5: Testing for Complementarity

The purpose of the fifth phase is to determine the presence of a complementarity between the level of investments and the level of the full-time labor. In order to do so, we utilize MR to test for the presence of statistically significant interaction term in the following formulation of the Translog function

$$\log Y =$$

$$= \beta_0 + \beta_{1*} \log K_{TC} + \beta_{2*} \log L_{TC} + \beta_{3*} \log K_{TC}^{\ 2} + \beta_{4*} \log L_{TC}^{\ 2} + \beta_{5*} \log K_{TC\,*} \log L_{TC} + e$$

Consequently, the test for the presence of the interaction involves testing of the following hypothesis: **H0: $\beta_5 = 0$.** For details regarding the theoretical background and description of the variables of the Translog model we direct our readers to (self-reference, IJPE, 2008). If the interaction term between investments and full-time staff is significant (i.e., we reject the null hypothesis of $\boldsymbol{\beta_5 = 0}$), then we have a reason to assume that such investments are complementary.

Phase 6: Determining the Intervention

The last phase of our methodology deals with the issue of determining an appropriate route of increasing the level of efficiency of the conversion of investments into revenues. In order to do so, we calculate the values of Malmquist index (MI) for DMUs in our sample. Keeping in mind that MI can be decomposed into two components, TC (change associated with changes in technology) and EC (change associated with changes in efficiency), we can determine which component contributes more to the overall change in efficiency of DMUs in the sample.

ILLUSTRATION OF THE METHODOLOGY

In the illustrative example we concentrate on the following 18 transition economies: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Poland, Romania, Slovakia, Slovenia, and Ukraine. The data for the period from 1993 to 2002 for these economies were obtained from the *World Development Indicators*[1] database, and the *Yearbook of Statistics*[2]. In our previous inquiry (self-reference, ESWA, 2007), we used Cluster Analysis (CA) to determine that our data set is not homogenous in terms of the investments in and revenues from Telecoms. By using CA we were able to come up with a solution that partitions our data set into two clusters. The membership of each cluster can be found in (self-reference, ESWA, 2007).

Phase 1: Identifying the Existing Inefficiencies

Once the results of CA were obtained, data set was partitioned into two subsets accordingly. Then output-oriented DEA was conducted to calculate the scores of the averaged relative efficiency for each cluster. A justification of the variables used to specify DEA model, as well as the list of variables, is provided in (self-reference, JITD, 2008). According to the results of DEA, one of the clusters has higher averaged scores of relative efficiency of production of revenues than the other cluster; we call the first group the *Leaders* and the second group the *Followers*. Results are presented in Table 4.

Average efficiency score	*Leaders* cluster	*Followers* cluster	Difference	Difference %
CRS	**1.94**	**2.54**	**0.60**	**23.67%**
VRS	**1.89**	**2.25**	**0.36**	**16.01%**
NIRS	**1.89**	**2.41**	**0.52**	**21.67%**

Table 4 Comparison of the clusters based on DEA (Output-Oriented Model)

The results of DEA allow us to identify the area of the greatest relative inefficiency in the production of revenues by the *Followers*. First, we partition the *Sales* curve into three areas: one area of VRS, one area of CRS, and one area of NIRS (see Figure 1). Let us recall that in this study we assume that a PLC *Sales* curve is S-shaped, and the models that use to produce S-shaped curves, such as logistic curve model or Gompertz model, produce areas of increasing, constant, and decreasing return to scale. Using information summarized in Table 4, we place the percentage scores of the relative efficiency of *Followers* on the corresponding areas of the curve. Based on the resulting diagram we isolate the area of greatest relative inefficiency, which in our case corresponds to the CRS part of the curve, and spans from the *Growth* stage to the *Maturity* stage of the *Sales* curve. We would like to provide some justification for why we isolated a part of the *Sales* curve and suggested that the assumption of constant returns to scale may hold for that area. It is commonly accepted that the sales of new products do not transition smoothly from *Introduction* phase to *Maturity* phase; instead, there is a *takeoff point* that signifies a transition from a “long introduction period when sales linger at low levels” to the period of “ rapid growth, associated with a huge jump in sales” (Trellis *et al.* 2003).

We argue that the part of the *Growth* phase after *takeoff point*, where the rate of growth may be higher than 400% (Golder & Tellis, 1997), is better suited to be modeled under the assumption of constant, rather than variable, returns to scale. We are

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[1] The World Bank’s comprehensive database on development data, found at www. web.worldbank.org/wbsite/external/datastatistics.

[2] Published yearly by the International Telecommunication Union (ITU), found at www.itu.int/ITU-D/ict/publications.

not making, however, any assumptions regarding the length of the period over which assumption of CRS might hold. Based on the results summarized in Table 4, we suggest that the area of the greatest relative inefficiency of the *Followers* is after the takeoff point, where "rapid growth requires extensive resources in terms of advertising, sales staff, manufacturing, distribution, and inventory support" (Trellis *et al.* 2003).

Phase 2: Modeling the Revenue Production Process

In order to model the processes of conversion of investments into revenues of the Leaders, we created a transfer function of NN first. We used *SAS Enterprise Miner* to do so.

Phase 3: Simulating the New Level of Revenues

During this phase we obtained the simulated outputs of the Followers and substituted them instead of their original outputs.

Phase 4: Determining the Sources of Inefficiency

At this point, we ran DEA again and recalculated the averaged scores of relative efficiency. We provide summarized results of the data analysis in Tables 5 & 6 below.

Average efficiency score	***Leaders* cluster**	***Followers* cluster**	**Difference**	**Difference %**
CRS	**2.09**	**2.30**	**0.21**	**-9.20%**
VRS	**1.38**	**2.00**	**0.62**	**-30.87%**
NIRS	**1.38**	**2.17**	**0.79**	**-36.26%**

Table 5 Comparison of the clusters, post-simulation (outputs of the *Leaders* simulated based on the processes of the *Followers*)

Average efficiency score	***Leaders* cluster**	***Followers* cluster**	**Difference**	**Difference %**
CRS	**2.04**	**1.62**	**0.42**	**25.62%**
VRS	**1.79**	**1.14**	**0.65**	**57.32%**
NIRS	**1.80**	**1.14**	**0.65**	**57.45%**

Table 6 Comparison of the clusters, post-simulation (outputs of the *Followers* simulated based on the processes of the *Leaders*)

The results summarized above allow us to conclude that the most effective strategy for the *Followers* is associated not with the increasing the level of investments in Telecoms, but with the improving the processes by which investments converted into revenues. According to the decision-making structure of our methodology we don't have to inquire, at this point, whether additional investments of the *Followers* should be complemented by the increase in the level of full-time employees; however, in order to demonstrate the capability of the proposed methodology, we will conduct the test next.

Phase 5: Testing for Complementarity

The results provide a sufficient evidence for the presence of complementarity between the levels of investments in Telecoms and full-time Telecom staff for the *Leaders* and *Followers*. However, the direction of the effect differs. Consequently, this allows us to conclude that any increase in the level of investments in Telecoms of the *Followers* should not be accompanied by the simultaneous increase in the level of full-time Telecom staff, for such increase will have a negative effect on the level of revenues.

Cluster	**Interaction Term in the model**	**Estimate (β)**	**p-value**	**Adjusted R^2**	**Result**
The "Leaders"	Log (Annual Telecom Investment)*Log(Full-time Telecom Staff)	57.4954	<.0001	0.9167	reject *H0* of no interaction

The "Followers"	Log (Annual Telecom Investment)*Log(Full-time Telecom Staff)	-2.1280	0.0087	0.9874	reject *H0* of no interaction

Table 7 Results of the MR

Phase 6: Determining the Intervention

As we can see, change in technology (TC) has a greater contribution to the annual changes in productivity than change in efficiency (EC). This gives us an indication that the *Followers* should address the inefficiency in EC component first, possibly by means of increasing the quality of their existing level of full-time workforce. The results of the analysis are summarized in Table 8 below.

Criterion for comparison	"*Leaders*" cluster	"*Followers*" cluster	Difference	Difference %
Malmquist Index (MI)	**1.17**	**1.20**	**-0.02**	**-1.79%**
MI, TC component	**1.10**	**1.14**	**-0.04**	**-3.83%**
MI, EC component	**1.09**	**1.08**	**0.02**	**1.45%**

Table 8 Comparison of the Leaders and Followers based on the DEA

Illustrative Example: Summary

The scenario of the illustrative example presented two groups of TEs over the period of 10 years, differentiated by their levels of investments and revenues from Telecoms. Some of these economies change their cluster membership depending on the year, while others keep their membership constant. The analysis of the relative efficiencies of the production of revenues identified one cluster, the *Leaders*, as being relatively more efficient in production of revenues than another cluster, the *Followers*. Assuming that the revenues are produced by the sales of Telecom products, which follows PLC model, we raised the question regarding the strategy according to which the *Followers* should go about increasing their level of production of revenues. By performing DEA and decomposing the PLC curve into the areas of constant, variable, and decreasing returns to scale, we identified the *Growth* phase as being the *Followers*' least efficient in terms of the production of revenues. But, keeping in mind the higher levels on investments of the *Leaders*, there was a possibility that the relative inefficiency of the *Followers* was due to their insufficient level of investments. However, sufficient evidence provided by NN simulation demonstrated that in the case of the Followers an increase in the level of investments would not be as beneficial as an improvement in the processes by which investments are converted into revenues. Results of MR further corroborated this finding by uncovering a negative interaction effect between the level of investments and the level of full-time labor of the *Followers*. Assuming that the inefficiency of the production of revenues could be caused by such factors as insufficient level of skills and knowledge of the full-time staff, as well as inadequate state of technology used by the full-time staff, it was important to discern which factor the *Followers* should target first. The use of MI allowed us to measure the changes in annual productivity of the Followers and to identify that EC component of MI, which reflects the level of efficiency of full-time staff, should be targeted for improvement first. As a result of the application of our methodology, we are able to formulate the following solution to the research question of the illustrative example: *In order to increase the level of revenues from Telecoms, the Followers should direct their effort at the improving the quality of the full-time Telecom staff involved in the Growth phase of the Sales curve of the Telecom product.*

CONCLUSION

In this paper we proposed a methodology for formulating empirically justifiable strategies for increasing the level of revenues from investments in Telecoms. The proposed methodology was tested in the context of the sample of 18 TEs. However, we suggest that the proposed approach also could be applied in formulating strategies of increasing level of revenues from other types of products, and not only Telecoms. Furthermore, our methodology could also be applied to the different level of analysis, such as an industry, a firm, or a department level. One of the strengths of our approach is based on utilization of the well-established and tested data analytical techniques. Our methodology is also theoretically sound, for it is supported by established frameworks. There are, nevertheless, some limitations to our approach as well. One limitation is associated with the relativity of the concept of efficiency; as a result, it is possible that the resulting strategies would be dependent on the choice of the peers involved in the comparison of the relative efficiencies. Another limitation is associated with the assumption of the availability of the resources required for increasing the relative efficiency of the production of revenues.

We hope, however, that the reader will find our study relevant and sound, and our paper as one having more strengths than limitations.

REFERENCES:

1. Bescherer, F. (2005). "Established life cycle concepts in the business environment introduction and terminology." Report 2005/1, available on line at http://www.tuta.hut.fi/library/raportit/teta_report/report%20Bescherer%20final1.pdf
2. Hauser, J., Tellis, J., and Griffin, A. (2005). "Research on Innovation: A Review and Agenda for Marketing Science", *Marketing Science*, Forthcoming Available at SSRN: http://ssrn.com/abstract=907230
3. Meffert, H. (2000). Marketing. 9th edition, Wiesbaden, Dr. Th. Gabler Verlag.
4. Piatkowski, M. (2003). "Does ICT Investment Matter for Output Growth and Labor Productivity in Transition Economies?" *TIGER Working Paper Series*, No. 47. December. Warsaw. Available at www.tiger.edu.pl
5. Sultan, F., Farley, J. U., and Lehmann, D. R. (1990). "A Meta-Analysis of Applications of Diffusion Models." *Journal of Marketing Research*, Vol. 27, No.1, pp. 70–77.
6. UN ICT Task Force Report (2005). Innovation and Investment: Information and Communication Technologies and the Millennium Development Goals. Report Prepared for the United Nations ICT Task Force in Support of the Science, Technologies and Innovation Task Force of the United Nations Millennium Project, available on-line at www.unicttaskforce.org/
7. Van den Bulte, C. and Stremersch, S. (2004). "Social Contagion and Income Heterogeneity in New Product Diffusion: A Meta-Analysis Test." *Marketing Science*, Vol. 23, No.4, pp. 530-544.
8. WT/ICT Development Report (2006). "Measuring ICT for social and economic development." International Telecommunication Union's World Telecommunication/ICT Development Report, 8th edition, available on line at www.itu.int/ITU-D/ict/publications